Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

EXPLORING THE ATMOSPHERE

BY WILLIS L. MOORE, LL.D. SC.D.

EXPLORATION into the realms of the upper air hold out entrancing allurements to the daring aviator. While the use of kites and balloons in sending automatic meteorological instruments aloft have revealed much more of the wonders of this heretofore uncharted wilderness of cold and partial or total darkness than the general public is aware, only the outer fringes of the mysterious region have been penetrated.

The geographic poles have been conquered and the jungles of Africa traversed; and deep borings have been made into the bowels of the earth until heat has seemed to arrest further progress. Fortunately it is easier to combat the cold of altitude than it is to contend against the heat that increases with descent into the earth. The exploration of both regions is of the utmost importance to the coming developments of civilization. It is not visionary to assume that the heat of one may in time furnish the power necessary to do the labor of mankind, give warmth and light to habitations and operate transportation systems. The conditions of the other offer pure, highly electrified and physically stimulating air into which dirigible ships may sail and in which they may remain for days and weeks with their multitudes of human passengers.

As mechanical appliances for operating in cold, rarified air are perfected it is probable that long-distance travel will be pursued mainly above the clouds and the whirling vortices of storms, where the air serenely follows its allotted pathways around the earth at velocities somewhere between one and two hundred miles per hour, and where the view is unobscured by clouds, fog or precipitation, and where the electrical potential, although high, is so homogeneously distributed that there is no danger of lightning stroke.

Ten years ago, in a number of Chautauqua lectures, the writer invariably was greeted with looks of incredulity when he prophesied that within a decade, travelers of the air would take breakfast in New York and afternoon tea in London. This is now an accomplished fact, and it is reasonable to assume that in the near future aerial navigation will be safer than travel by rail or automobile. The hitherto inaccessible parts of the earth's surface will be sailed over and closely scrutinized while enjoying all the comforts that heretofore have been associated with Pullman service.

In 1862-66 Glaisher, the English meteorologist, ascended in a balloon to about the same height as that attained by Major R. W. Schroeder, of the United States Army, who achieved a much more difficult feat when he flew in an aeroplane to over 36,000 feet. These are the extreme altitudes to which human beings ever have attained, but they are probably only the beginning of explorations into a vast and largely unknown and extremely cold region,—one in which darkness increases with elevation, until at the outer limits of the atmosphere no illumination whatever exists.

The terrific eastward wind, and 69 degrees below zero, encountered by Major Schroeder are conditions that already had been revealed by the work done at the research station of the Weather Bureau, at Mount Weather, Va., and by ascensions at the Blue Hill Observatory of Massachusetts, and at European stations. Balloons flown from Mount Weather reached greater heights than were attained anywhere else in the world, 19.1 being the extreme altitude gained. The beginning of ascensions were made in the Rocky Mountains with balloons, hydrogen gas and meteorographs sent from Mount Weather. A large number of these instrumental weather explorers were liberated and reached great altitudes—15 to 19 miles—as they swiftly drifted eastward in the stratum above storms.

In 1898, under the direction of the writer, 1200 observations were made with kites by observers of the U. S. Weather Bureau at seventeen selected stations, during the six warm months from May to October. We were surprised to find that the loss in temperature for the first 1000 feet ascent during extremely hot periods was as much as 15 degrees, and the average decrease in temperature per 1000 feet elevation for all stations for all times, and at all elevations up to 5280 feet, was 4 degrees.

For over five years kites were used at Mount Weather to carry instruments aloft to heights ranging from two to four and one-half miles, and to keep the apparatus up several days at a time, so that a continuous record might be secured of all hours of the day.

Few are aware that the rectangular kite of the meteorologist was the forerunner of the aeroplane of the aviator. In 1903, while directing Weather Bureau experiments at Roanoke Island, N. C., the writer saw the Wright brothers, or their representatives, lying flat upon their backs on the lower plane of what appeared to be Weather Bureau kites and gliding in the air from the top of sand dunes. This was the beginning of real flight by man. The ingenuity of the Wrights transformed the weather man's kite, strengthened it, took out the ends, hitched on a rudder, and when the petrol engine had developed sufficient power with a given weight, installed it, and flew.

In the future the meteorologist and the aviator will be closely associated. With observations made from aeroplanes simultaneously at a number of Weather Bureau stations and included in the telegraphic reports to Washington, it will be possible to make highly accurate forecasts for all parts of the country with respect to the incipient whirls or vortices so much feared by aviators, and for weather, wind direction and velocity at various high levels; and it should be borne in mind that all these conditions may be quite different in the upper reaches of the air to what they are at the surface of the earth.

Brigadier-General William Mitchell, Chief of Army Aviation, in an interesting lecture delivered before the Cosmos Club in Washington on May 25 last, spoke of the necessity for active co-operation of the meteorologist to aid in the construction of daily high-level weather charts as well as the making of forecasts of wind direction and force for the upper regions, where such extensive travel will occur in the future. All the data that the meteorologist needs is pressure, temperature and clouds. When he has plotted each in its proper geographic position, the barometer readings from say fifty stations east of the Rocky Mountains, taken at 15 or 20 thousand feet elevation, which is about midway between the bottom and the top of cyclonic storms, and drawn in the isobaric curves that connect stations of the same pressure, he knows precisely the direction and velocity of the wind without the use of other information, the pull of gravity causing the wind to move from a region where the barometer is high and the pressure great toward a region where the barometer is lower and the pressure less. The scientist knows that it will blow with a velocity directly proportional to the difference in pressure. The low pressures or storm-centers, with their vast systems of spirally inflowing and upwardly moving winds, warmth, clouds and precipitation, are definitely located by the barometric curves, as, also, are the high-pressure or cool, clear and stable areas wherein all the conditions of the low-pressure are reversed, the air moving downward in the region of the high-pressure center and outward along the surface of the earth. The present weather map is based upon barometric readings corrected so as to read what they would if the cisterns of the barometers were exactly at sea level.

The purpose now is to construct, with the aid of aviators securing the observations, a daily chart on which all barometers shall either be read at the four-mile level above the earth or else their readings corrected so as to read the same as they would if the instruments were at the exact level desired. Then the horizontal gradients of pressure on the selected level are established and the weather chart is ready for the interpretations of the skilled forecaster. This coöperation of the bird-man and the weather-man in studying the geography of the new air-world will mark an epoch in meteorological science as far reaching in its consequences as were the discovery of the barometer by Torrecelli and the uncovering of the principles of the thermometer by Gallileo, neither one of which were known until twenty-three years after the landing of the Pilgrims at Plymouth Rock. Thus swiftly does the mind of man explore the hidden recesses of Nature's mysteries, and with each conquest carry itself to higher realms of existence.

By comparing the sea-level and the high-level chart it will be possible to establish the vertical gradients of pressure and temperature in the four quarters of both cyclones and anti-cyclones and for the first time be able mathematically to discuss the mechanics of storms, so that weather forecasting may evolve from impericism to something closely approaching scientific deductions of exactitude.

In the not distant future more forecasts and storm warnings will be issued by the Weather Bureau for ships of the air than for those of the sea; the navigation of the air must play an increasing and important part in the coming activities of the world.

Science is becoming so skillful in harnessing the forces of Nature to man's desires and in the development of mechanical appliances that it is reasonable to anticipate that within a quarter-century or less human beings will be nearly as numerous as insects in the air, will remain aloft longer and sail to vastly higher altitudes. It is well therefore to know something of what science has learned about this new world into which man is projecting himself.

Immediately after this country entered the World War the National Advisory Committee for Aeronautics published in elaborate form the results of the researches made at Mount Weather and put them into the hands of all the fighting aviators. These sailors of the atmospheric ocean were benefitted by the meteorological explorers who had preceded them with the kites, balloons and meteorographs of Mount Weather. There was ready for the use of the Army at the front a fund of useful information of a region that but a short time before was entirely uncharted and in which they must engage in mortal combat. The conditions found by Major Schroeder were all described in this report by the Committee on Aeronautics, just as the courageous sky traveler found them. The instruments carried by the exploring balloons had keen scientific eyes and they recorded on clock-timed cylinders what they saw. When the balloons burst as they did finally as the result of the loss of density with increasing elevation, the instruments slowly descended under parachutes that conveniently opened for the purpose of staying rapid descent. In this publication, wind, clouds, temperature and other conditions were tabulated and charted for all levels likely to be reached by the fighters. A pilot was able to determine at a glance at what level and in what direction his wind would shift as he rose and he was given a fair approximation of the velocity that he might expect.

Had not the Committees in Congress supported me with the necessary appropriations to construct Mount Weather and carry on this special research work during the preceding ten years there would have been no source in this country whence such data could be secured and no source in any other country whence such a complete series of extremely high-level observations could be obtained.

We now know that the temperature falls rapidly with ascent,—about one degree for each 300 feet,—until the top of the storm level is reached, at seven miles, when a most wonderful thing ensues:—the thermometer no longer falls as the balloon rises; it remains practically stationary so far as exploration has been made, which is to the height of over nineteen miles.

We have named this region above the storms the Isothermal (equally heated) Region. Its temperature everywhere is about 60 degrees Fahrenheit below zero and it changes only about 8 degrees between winter and summer. Of course one must assume that ultimately the temperature shades away to practically nothing as outer space is reached. Outside of the earth's atmosphere,—the oxygen of which ceases at about thirty miles, the nitrogen at fifty and the the hydrogen and helium at about two hundred miles,—there is total darkness even at midday, and little or no temperature—over 400 degrees below zero in the intensity of its cold.

Observations show anomalies that are startling. At one and one-half miles high there is little difference between midday and midnight, except that the coolest time of the twenty-four hours is during day time and not at night, as would be most naturally supposed. This is important information to an aviator or to the pilot of a ballon. As previously stated, at the height of only 1000 feet in free air at the hottest time of midsummer's heat, the air is found to lose as much as 15 degrees in comparison with that at the ground. Almost within arm's length of the streets of great inland cities there is a cool and healthful atmosphere when humanity is sweltering and dying from heat below. May not several Eiffel towers for each sanitarium some day sustain them far above the tallest sky scrapers of the present—1000 or 2000 feet high.

At the height of ten miles it would be difficult to hear the human voice because of the attenuated medium of transmission, and the twilight would deepen, even though it were midday. At thirty miles there would be no oxygen, one's voice could not be heard at all, and the stars would come out and darkness ensue although it were bright sunlight below. The nitrogen would cease at about fifty miles.

The traveler in the upper levels can carry oxygen and make air as he needs it, and he can insulate himself against the cold of this new world, which he will find deficient in dust motes and doubtless entirely wanting in the bacteria of putrefaction and disease. There will be no clouds to obscure his vision, nor rain, nor snow. He will not often ascend above the region where there are not some dust motes to scatter and diffuse a part of the solar rays and give him light, or at least a partial illumination. Above the nitrogen there are only the hydrogen and the helium, the two lightest of all gases. These make themselves manifest as far out as two hundred miles from the earth in their warming effects on meters that shoot into them and become luminous by the heat of friction.

The darkness of outer space may be proven by taking an enclosed volume of air, free it of dust motes, of which there are millions per cubic centimeter, and then try to illuminate it, and it will be found that no matter how powerful the light that is directed into it it remains wholly dark. When one looks up at midday he apparently sees the whole universe illuminated; but in point of fact only the thin stratum of the earth's air in which he lives is illuminated. Outer space is practically without temperature or light. The rays of the sun do not become either light, or heat, or electricity until they encounter the denser molecules of the air near the earth and the invisible dust-motes and cloud-particles in suspension in the air, and through such interference are transmuted from etheric vibrations into other forms of energy—heat, light, electricity, etc.

Few persons are familiar with these simple problems of the phenomena of the air, which have such an important bearing on the distribution of corporal man into realms above what he has been accustomed to inhabit.

The northwest wind always brings physical energy and mental buoyancy, because it has a downward component of motion that draws air from above, where it is free of impurities and where high electrification has changed a considerable quantity of its oxygen into ozone, in which condition it remains but a short time after reaching the lower potential near the earth's surface. More people die under the enervating influence of the south wind than under the influence of the north wind, because the south wind hugs the surface of the earth and becomes laden with impurities and is lacking in electrical stimulation.

When inventive man becomes more familiar with the ocean on the bottom of which he has lived so long, he will not wait for the north wind to bring down to him the benefactions of higher up; he will go after them and remain aloft as long as he desires to do so.

The further development of the dirigible balloon and the aeroplane are among the most important functions of the engineer of the future. The meteorologist must establish the climatology of various strata above the earth. Mount Weather, instead of being abandoned, as it has been by the present Administration, should be operated on an enlarged scale and other institutions of similar purpose established. No autocratic old woman with a broom should be allowed to sweep back the progress of science in exploring the nearly untracked wilderness above the earth, for here man will largely disport himself in the time to come. The hanging gardens of Babylon will be outdone in the twentieth century and the eyrie of the eagle left far below by those who will live a part of their time in elevated structures having bases resting upon the earth.

Before travel in the isothermal stratum, above storms, is frequent or protracted some engineering difficulties must be overcome, but these are in process of solution by some of the ablest inventors of the world. In this region there is only one-fourth of an atmosphere, with 60 degrees below zero temperature, and it is necessary not only to warmly enclose and insulate passengers and pilots, but to feed the carburetter of engines with air artificially regulated to pressures and heat so as to be somewhat comparable to what the engine used at lower levels; and the ratio between power and the size of propellers must be adjustable so as to maintain efficiency in the extremely rarefied sailing medium.

Why should not eclipses and other astronomical events be regularly observed from great aeroplanes, or preferably from monster dirigible air ships elaborately equipped for observational work above the optical disturbing effects of clouds, dust and the heterogeneously heated lower air? The possibilities of research and discovery are almost limitless.

WILLIS L. MOORE.